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MEMORANDUM

To:	Steve Klein	cc:	John Bradley, Gary Smith, Bill Oleyar
From:	David M Smith		
Date:	November 13, 2003		
Ref:		Page:	1 of 2
Subject:	IPP Motor Rating Questions		

Steve,

At the kick-off meeting with IPP we obligated ourselves to provide support for the determination of the existing ID fan motor's ultimate power capability. I have made a review of the existing motor data and design requirements and from this some questions do arise.

The existing ID Fan motor was supplied with the following ratings for operation from an LCI type of variable frequency drive system at 4,676 ft ASL and 45 °C ambient:

1. Base Rating of 7,415 Hp, 6 phase, 954 rpm, 3,876 volts, 472 A, 0.9 PF with 75 °C temperature rise.
2. 6 pulse rating of 4,596 Hp, 3 phase, 809 rpm, 3,876 volts, 538 A, 0.9 PF with 75 °C temperature rise.
3. 6 pulse rating of 4,590 Hp, 3 phase, 743 rpm, 3,560 volts, 646 A, 0.9 PF with 100 °C temperature rise.

(Data source – Westinghouse Outline drawing 2136 F72 rev. 5 and document 1729AADATAPACK.txt by J. Portos 8/28/03)

Question 1 – Do Teco-Westinghouse agree with the above design data?

From the project specifications and discussion with IPP's Mr. Jon Christensen we also have the following requirements for future operation of the motor with the same type of drive and ambient conditions:

1. 8,200 Hp, 6 phase, 954 rpm, 0.9 PF
2. 10,000 Hp, 6 phase, 1,050 rpm, 0.9 PF
3. 5,300 Hp, 3 phase, 850 rpm, 0.9 PF

Question 2 – Is the existing motor designed to operate continuously at 1,050 rpm?

Some discussion of the future requirements follows:

1. 8,200 Hp at 954 rpm implies an increase in operating voltage or current or a combination of the two by 8,200/7,415 = 1.106 times the base rating for the motor i.e. approximately 10%. Comparison of design point 3 with design point 2 suggests that operation is possible to 646/538 = 1.2 pu current i.e. a 120% increase in current to reach 100 °C rise (or even higher as design point 3 is at a lower speed than design point 2). Therefore, an increase in current of more than 10% can be accommodated by allowing the motor temperature rise to exceed 75 °C. However, by increasing the motor's operating voltage by 10% it may be possible to achieve the desired power increase without exceeding the 75 °C temperature rise. This would require that the motor operate at 4,286 volts instead of 3,876 volts. The volts per rpm at this level (an indication of the working flux level of the machine) would be 4,286/954 = 4.493 whereas the volts per rpm from design point 3 is 3,560/743 = 4.791. This suggests that the machine would be capable of operating this way provided that the motor stator's insulation system is suitable

ALSTOM Power Conversion
610 Epsilon Drive
Pittsburgh, PA 15238 USA
Tel.: +1 412 967 0765
Fax: +1 412 967 7660

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for 4,286 volts. NEMA standard MG1 requires motors of this type to be built with the capability to operate at up to +10% supply voltage.

Question 3: - What is the maximum recommended operating voltage for the motor?

2. 10,000 Hp at 1,050 rpm implies a further increase in voltage and/or current by an additional 22% over the 8,200 Hp requirement. If operated at +10% voltage, as proposed for operation to 8,200 Hp the per winding current would then be approximately: -

   Iac = (10,000 x 746)/(√3 x 4,286 x 0.9 x 0.97 x 2) = 575 A (assumes 97% motor efficiency)

   This value is 22% higher than the base rating current level of 472 A as expected but it is lower than the design point 3 current capability of 646 A at 743 rpm. Plus, additional cooling air will also be available at the higher operating speed.

   On this basis it would appear that operation to 10,000 Hp at 1,050 rpm would be possible within the class F temperature rise of +100°C.

Question 4: - What is the predicted temperature rise for this operating condition?

3. 5,300 Hp at 850 rpm is perhaps the worst of the three requirements as this requirement extends the three phase loading beyond the design point of 4,590 Hp at 743 rpm and may be considered somewhat equivalent to operation with six phases at 10,600 Hp. However, design point 3 does permit operation to 646 A within a class F temperature rise. Operation at the same voltage to rpm ratio as is permitted for design point 3 leads to an operating voltage of 4,073 volts (+5% over the base voltage rating) at 850 rpm where the current required to operate at 5,300 Hp would be:-

   Iac = (5,300 x 746)/(√3 x 4,073 x 0.9 x 0.97) = 642 A (again assumes 97% motor efficiency)

   This value is in line with the design point 3 value suggesting that the motor operating conditions for the new requirement would be very similar to the design point 3 operating condition but at a higher speed and voltage. Assuming that the higher voltage can be accommodated, the higher operating speed should provide additional cooling and so improve the operating conditions over those for design point 3.

Question 5: - What is the predicted temperature rise for this operating condition?

Summary Remarks:

The new drive units are being built to be capable of operation to 4,286 volts (+10%) and 642 A ac (823 A dc) but the existing transformers and chokes will not support this (max 768 A dc continuous). However, operation to +10% motor voltage should be possible with the existing equipment and short time operation to 823 A dc would permit operational tests to be conducted at all three of the new requirement points. Thermal testing of the motor and continuous operating duty will not be possible at the new requirement points 2 and 3 without first up-rating the transformers and chokes.

Some remaining questions:

Question 6: - Is the motor's insulation system suitable for operation with one phase grounded?

Question 7: - The motor test data provided indicates that the motor may be capable of operation to 4,476 volts and 817 A ac – is this a correct interpretation of the data provided?